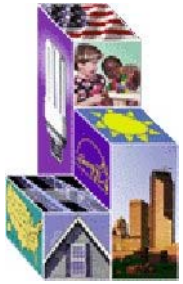
Commercial Unitary Air Conditioners
and Heat Pumps

Life Cycle Cost Analysis

James E. McMahon
(JEMcMahon@LBL.gov)
Ernest Orlando Lawrence Berkeley National Laboratory

U.S. DOE Workshop on Standards
for Commercial Unitary Air Conditioners
and Heat Pumps
October 1, 2001



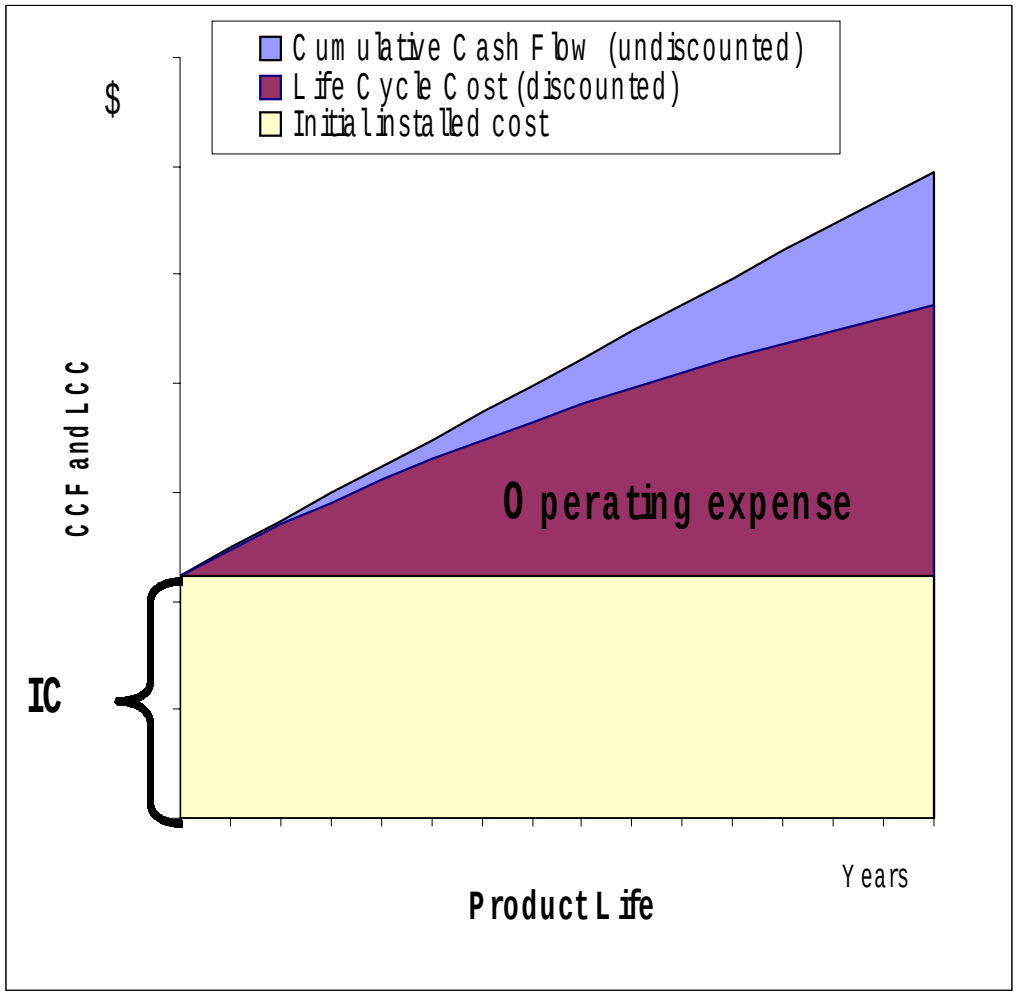
Life Cycle Cost Analysis:
Purpose

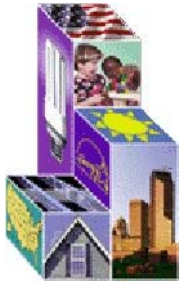
- Analyze "the savings in operating costs throughout the average life of the covered product in the type (or class) compared to any increase in the price of, or in the initial charges for, or maintenance expenses of, the covered products which are likely to result from the imposition of standards."

  (§325 (0)(2)(B)(i)(II)) [EPCA]

Life Cycle Cost is the Sum of Initial Cost and Lifetime Operating Costs

- LCC = IC + $\Sigma[O/(1+r)^t]$ where
  - IC = Initial installed cost
  - O = Annual operating expense
  - r = Discount rate
  - t = years (sum over equipment lifetime)



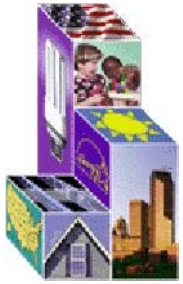


Life Cycle Cost Analysis: DOE Requests Input from Stakeholders

- *Are the proposed approaches reasonable?*
- *Should regional variations in climate and energy price be analyzed in ANOPR stage or later (NOPR)?*
- *Are the proposed data sources reasonable?*
- *Should equipment lifetimes depend on operating hours, climate, or other application-specific variables? Should lifetimes be the same for all product classes?*

Life Cycle Cost Analysis: Inputs (1)

- Installed Cost:
  The price paid for an air conditioner or heat pump, including installation
- Possible data sources
  - Current or recent purchase prices
  - Calculated from manufacturer costs plus markups (manufacturer, dealer, distributor, contractor) plus sales tax and installation cost

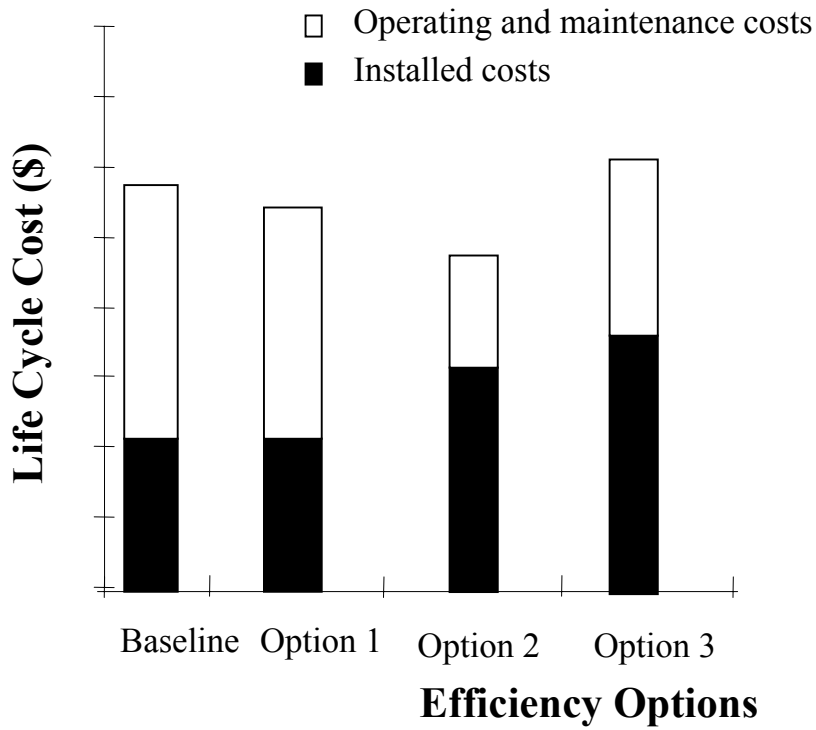


Life Cycle Cost Analysis: Inputs (2)

- Operating Expenses:
  - Energy and maintenance costs
  - Lifetime of the air conditioner or heat pump
  - Discount rate (for calculating present value of future operating expenses)
- Possible approach and data sources
  - Annual energy consumption by air conditioner or heat pump (derived from CBECS, other commercially available data sets and/or simulations)
  - Current and forecasted regional energy price trends (from EIA/AEO) applied to marginal prices
  - Gather and analyze data on lifetimes, discount rates
  - Survey of commercial tariffs and utility marginal costs

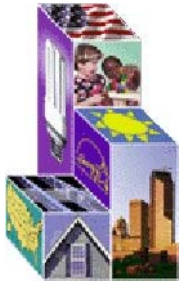
Life Cycle Cost Analysis:
Illustrative LCCs for Generic Options

- A range of efficiencies will be analyzed and compared to baseline.
- In this example, 3 options have reduced operating costs
  - Option 1 = lower LCC
  - Option 2 = lowest LCC, but higher installed costs
  - Option 3 = higher LCC and highest installed costs



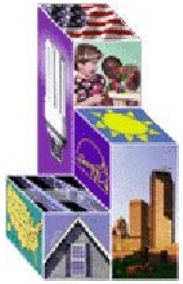
Life Cycle Cost Analysis: Analyze Variability and Uncertainty

- Objectives:
  - Analyze variability among applications and operating conditions (e.g., climate, building characteristics, operation, electricity prices)
  - Rigorous treatment of uncertainty
- Technical Approach:
  - Use commercially available software
  - Use distributions for each input, not point estimates
  - Public access via Web, training



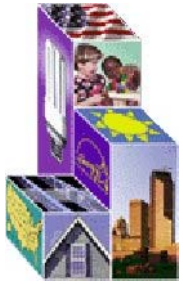
Life Cycle Cost Analysis: Analysis Issues

- Whose Perspective
  - Owner
  - User
- Demand Charges
  - Highly variable
- Utility Deregulation
  - Future developments
  - Price impacts



Life Cycle Cost Analysis: Results

- Summarize Results for Each Possible Efficiency Improvement
  - Average (or median) LCC savings
  - Percent of consumers with net savings or with net costs
- Importance analysis
  - Identify key inputs that contribute most to uncertainty or variability

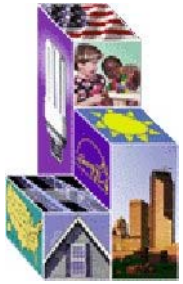


BACKUP SLIDES

Life Cycle Cost Analysis

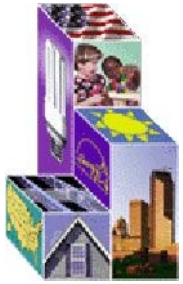
Life Cycle Cost Analysis: Uncertainty and Variability

- Identify key sources of uncertainty and variability
  - Uncertainty: incomplete information
  - Variability: range of values
- Estimate input ranges rather than point values
  - Minimum, likeliest, maximum values
- Conduct scenario ("what-if") analysis
- Simulate over input ranges
- Express output as ranges
  - Summarize with percent of consumers having lower life cycle cost



Life Cycle Cost Analysis: Simulation Method

- Select one building from sample population
  - Use weighted sampling (to represent appropriate fraction of total population)
  - Actual monthly energy bills
  - Estimate annual energy consumption by air conditioner or heat pump
- Calculate price of energy
  - Calculate marginal price for electricity
  - Apply time trends to estimate future prices
- Sample given uncertainties
  - Manufacturers' costs, markups, lifetime, discount rate
- Calculate LCC



Process for making models transparent and robust

- Make models as simple as possible
- Make copies of models accessible to public
  - On Internet
  - Available from US DOE or contractor
- Make models easy to use
  - Graphical user interface, option menus
  - Develop documentation
- Provide training
  - Central location (e.g., public workshop)
  - On-site at stakeholder location
  - Computer link or videoconference